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955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: September 2, 1971
to: Distribution
from: K. P. Klaasen
subject: Feasibility of Candidate Apollo 16
Lunar Surface Timelines -- Case 310

B71 09004

ABSTRACT

Preliminary Apollo 16 lunar surface timelines have been constructed. Task times assumed for various lunar surface activities were those used in preliminary Apollo 15 planning. The first EVA was scheduled immediately after touchdown, and no standup EVA was included.

A timeline with three EVA's (6,7,7 hours) totalled 67.75 hours. This timeline is feasible from a LM descent consumables standpoint although the projected H₂O margin is only 3 lb.

A timeline with four EVA's (6,7,7,7 hours) totalled 79.17 hours. This timeline pushes the system capability very hard; however, the additional scientific return from seven more hours of surface EVA may justify the sacrifices required to make such a timeline feasible. The projected LM descent consumables margins are 12 amp-hr of battery charge and -61 lb of H₂O. Since the currently planned H₂O load is 408 lb and the tank capacity is 666 lb, additional H₂O could be loaded to provide a positive margin at the expense of some available descent hover time. Additional provisions required for a fourth EVA would also increase LM weight and decrease hover time. Other lower-priority items that contribute to total LM weight would have to be eliminated to provide the capability for such an extended lunar stay with four EVA's. LM systems are currently qualification tested for surface stays of only up to 72 hours, and longer stays would require special approval. A 72-hour stay is the minimum stay for which four EVA's will yield at least as much EVA time as a three-EVA timeline.

(NASA-CR-121682) FEASIBILITY OF CANDIDATE
APOLLO 16 LUNAR SURFACE TIMELINES (Bellcomm,
Inc.) 11 p

N79-71714

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FF No. 60 CX-121602
(NASA CR OR TMX OR AD NUMBER) (CATEGORY)
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MEMORANDUM FOR FILE

Introduction

Lunar surface timelines should be designed so as to allow for the maximum amount of scientific return while meeting the operational constraints imposed by the equipment or crew. The Apollo 16 crew has expressed a preference for a timeline that calls for a lunar surface EVA immediately after touchdown and includes no standup EVA (SEVA). Mention has also been made of increasing the number of surface EVA's from three to four to increase the scientific return. Preliminary lunar surface timelines have been constructed for analysis of their crew work/rest cycles and LM consumables requirements. Timelines with three EVA's of 6,7,7 hours duration and with four EVA's of 6,7,7,7 hours duration were examined.

Candidate Lunar Surface Timelines

In constructing the candidate timelines, the times required to perform various activities on the lunar surface were taken to be those used in preliminary Apollo 15 planning (Reference 1):

Post-touchdown activities	1.25 hr
Eat	.75
Pre-EVA briefing	.17
Don or doff suits	.50
EVA preps (first EVA)	2.00
EVA preps (subsequent EVA's)	1.75
Post-EVA activities	1.50
Post-EVA debrief	.25
Pre- or post-sleep activities	.25
Sleep	8.00
P57 power up	.25
Pre-liftoff activities	1.25



The minimum eight-hour sleep period required by the Medical Research and Operations Directorate (MROD) at MSC has been maintained, and the EVA periods are a maximum of seven hours in duration. The time blocks listed above are only approximate, and later adjustments can be made to the timelines to fit them into the interval from touchdown to liftoff in the final flight plan.

A candidate timeline with three EVA's of 6,7,7 hours duration is shown in Figure 1. The total lunar surface stay time is 67.75 hours. Assuming the crew is awake 9-10 hours before touchdown, the first day on the surface will total about 23 hours between rest periods.

A timeline with four EVA's of 6,7,7,7 hours duration is shown in Figure 2. This timeline totals 79.17 hours on the surface and involves both a long touchdown day (about 23 hours) and a long liftoff day (about 22 hours). Qualification testing of LM systems is currently done only for a 72-hour stay; however, with sufficient motivation longer stays could be approved.

Either timeline can be shortened simply by reducing EVA time. For example, the four-EVA timeline could be reduced from 79 hours to 75 hours by making the EVA's 5,6,6,6 hours in duration. A 72-hour stay is the minimum stay for which four EVA's will yield at least as much EVA time as a three-EVA timeline. Sleep periods could also be shortened; however, since lunar surface sleep periods have tended to be shortened or at least degraded on past missions, planning sleep periods of less than eight hours is not advisable especially in the four-EVA case when long work days are required for both touchdown and liftoff days.

LM Descent Stage Consumables Usage

Approximate LM descent stage consumables usage rates have been calculated from Apollo 15 pre-mission data (Reference 2). The rates are as follows:

Electrical current - 20.3 amp

H₂O - 25 lb/EVA, 3.37 lb/hr

O₂ - 7.3 lb/EVA, 5.8 lb for cabin repress
after equipment jettison, .196 lb/hr
in pressurized LM.

These usage rates were used to estimate the consumption during the surface stay for each of the candidate timelines.



The consumables usage summary for the 67.75-hour stay with three EVA's totalling 20 hours is shown in Table 1. Substantial margins are available in battery charge and O_2 . Descent H_2O shows a margin of only 3 lb. The battery charge requirements include 63 amp-hr for one contingency revolution before liftoff. The H_2O and O_2 required for such a revolution are considered to be available from the LM ascent stage tanks.

Table 2 shows the consumables usage summary for the 79.17-hour stay with four EVA's totalling 27 hours. The descent H_2O has a negative margin of 61 lb in this case, and the margin in battery charge is down to only 12 amp-hr. The currently planned load of 408 lb of H_2O does not fill the tanks to their capacity of 666 lb. More descent H_2O could be loaded to provide a positive margin at the expense of DPS, SPS, and launch vehicle propellant reserves. The current Apollo 16 LM weight is 69 lb under its control weight (4 sec of descent hover time) while SPS and launch vehicle reserves are relatively large (Reference 3). Loading an additional 61 lb of H_2O onboard would reduce the available descent hover time by about 3.5 sec. Additional provisions required for a fourth EVA would also increase LM weight and decrease the available hover time.

LM descent consumables usage may be quickly estimated for other lunar surface timelines using the usage rates listed above since the total lunar surface requirements are relatively insensitive to parameters other than total stay time and the number and duration of the EVA periods. For example, the 75-hour stay mentioned above with four EVA's totalling 23 hours will result in margins of 97 amp-hr in battery charge and -47 lb in H_2O .

Summary

A 67.75-hour lunar surface timeline with three EVA's totalling 20 hours is a well-filled timeline and is feasible from a LM descent consumables standpoint although the projected H_2O margin is somewhat small for the currently planned load. A 79.17-hour timeline with four EVA's totalling 27 hours pushes the system capability very hard; however, the additional scientific return from seven more hours of surface EVA may justify the sacrifices required to make such a timeline feasible from a consumables standpoint. To provide the capability to carry the extra H_2O and provisions required for an extended surface stay with four EVA's, the available descent hover time must be reduced and/or other items contributing to total LM weight (such as equipment, experiments, other consumables, etc.) must be eliminated. LM systems are currently qualification tested



for surface stays of only up to 72 hours, and longer stays would require special approval. A 72-hour stay is the minimum stay for which four EVA's will yield at least as much EVA time as a three-EVA timeline.

2013-KPK-jab

Attachments

K.P. Klaasen

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REFERENCES

1. "EVA Timeline on Apollo 15," MSC telecon with Dr. Petrone, January 13, 1971.
2. "The Final Consumables Analysis for the Apollo 15 (Mission J-1) Spacecraft Operational Trajectory (July 26, 1971 Launch Date)," MSC Internal Note No. 71-FM-279, July 16, 1971.
3. "Apollo Spacecraft Weight Status Summary," Manned Spacecraft Center, August 15, 1971.

BATTERY CHARGE

Initial Capacity	2075 amp hr
Unusable	- <u>101</u>
Usable	1974
Required to Touchdown	- <u>292</u>
Usable on Surface	1682
Required on Surface	- <u>1375</u>
Usable Remaining	307
Contingency Rev ⁽²⁾	- <u>63</u>
Margin	244

H₂O

Initial Load ⁽³⁾	408 lb
Unusable	- <u>62</u>
Usable	346
Required to Touchdown	- <u>40</u>
Usable on Surface	306
Required on Surface	- <u>303</u>
Margin	3

O₂

Initial Load ⁽³⁾	94 lb
Unusable	- <u>5</u>
Usable	89
Required to Touchdown	- <u>2</u>
Usable on Surface	87
Required on Surface	- <u>37</u>
Margin	50

(1) Data from Reference 2 except amounts required on surface and initial H₂O and O₂ loads.

(2) From Reference 1.

(3) From Reference 3.

TABLE 1 - LM DESCENT CONSUMABLES USAGE
FOR 67.75-HOUR LUNAR SURFACE STAY WITH 3 EVA's⁽¹⁾

BATTERY CHARGE

Initial Capacity	2075 amp hr
Unusable	- <u>101</u>
Usable	1974
Required to Touchdown	- <u>292</u>
Usable on Surface	1682
Required on Surface	- <u>1607</u>
Usable Remaining	75
Contingency Rev ⁽²⁾	- <u>63</u>
Margin	12

H₂O

Initial Load ⁽³⁾	408 lb
Unusable	- <u>62</u>
Usable	346
Required to Touchdown	- <u>40</u>
Usable on Surface	306
Required on Surface	- <u>367</u>
Margin	-61

O₂

Initial Load ⁽³⁾	94 lb
Unusable	- <u>5</u>
Usable	89
Required to Touchdown	- <u>2</u>
Usable on Surface	87
Required on Surface	- <u>45</u>
Margin	42

(1) Data from Reference 2 except amounts required on surface and initial H₂O and O₂ loads.

(2) From Reference 1.

(3) From Reference 3.

TABLE 2 - LM DESCENT CONSUMABLES USAGE
FOR 79.17-HOUR LUNAR SURFACE STAY WITH 4 EVA's⁽¹⁾

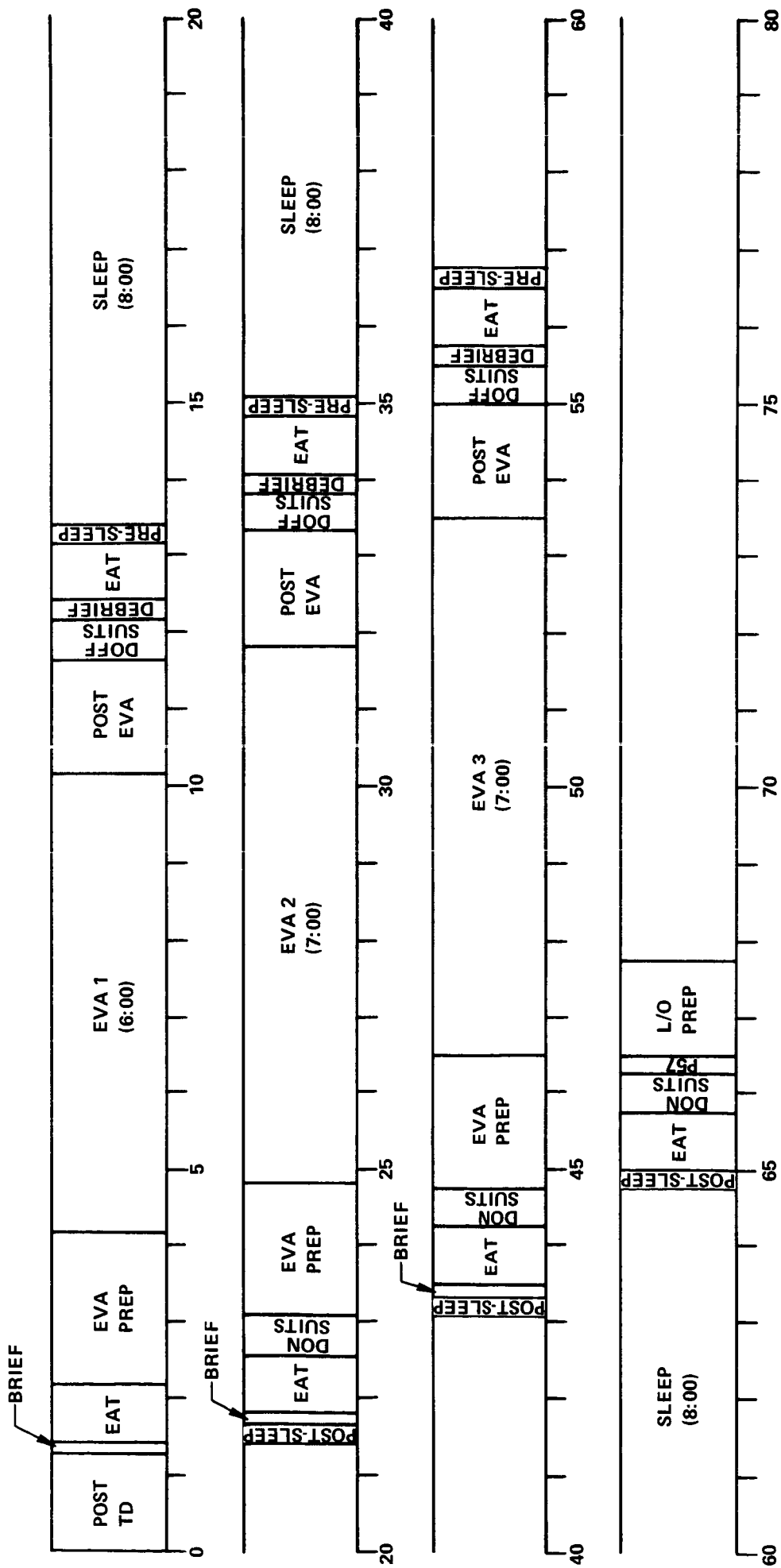


FIGURE 1 - APOLLO 16 67.75-HR LUNAR SURFACE TIMELINE WITH THREE EVA'S (6, 7, 7 HOURS)

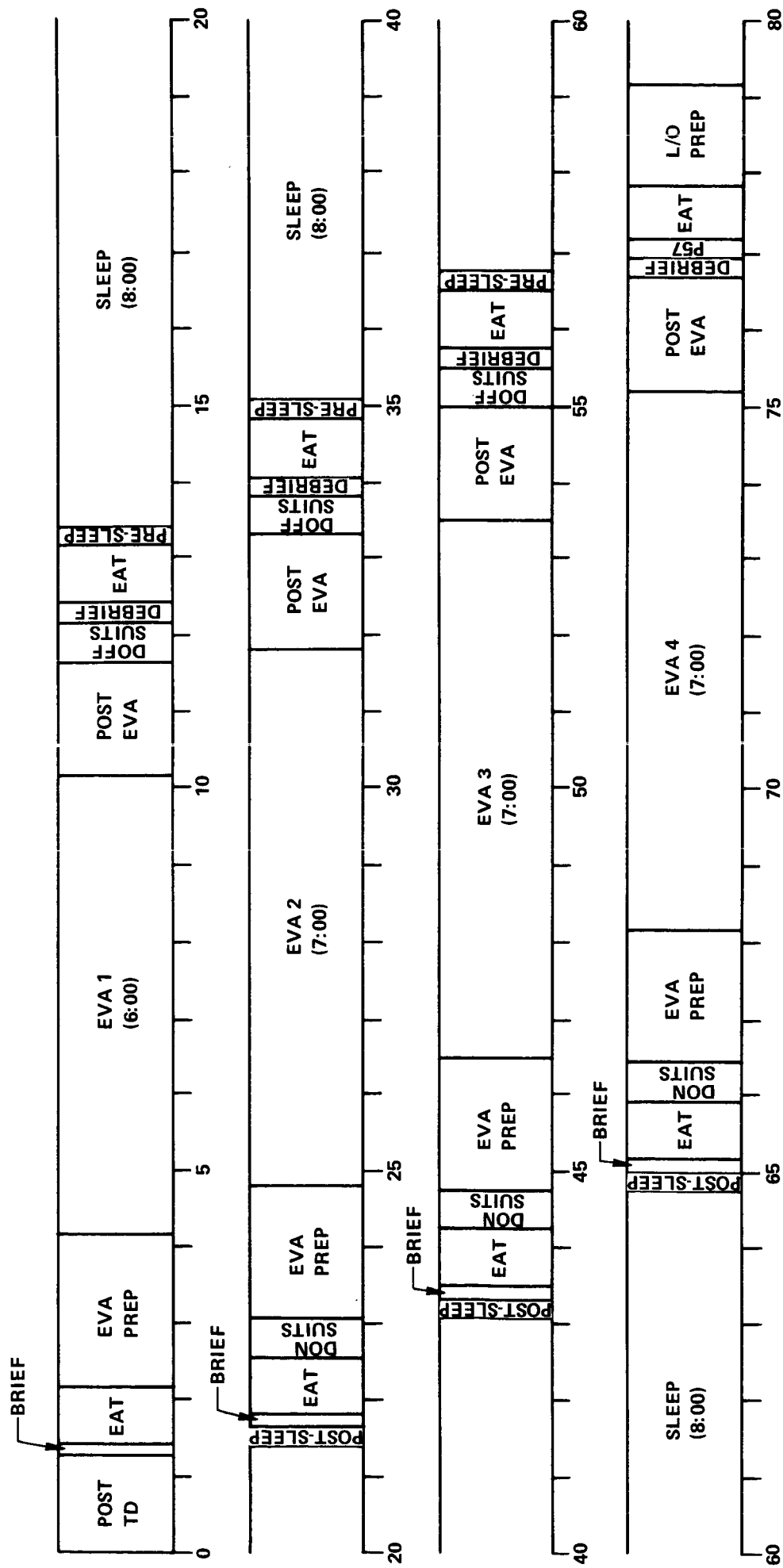


FIGURE 2 - APOLLO 16 79.17-HR LUNAR SURFACE TIMELINE WITH FOUR EVA'S (6, 7, 7, 7 HOURS)



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